ROBUSTNESS OF DISCRETE LINEAR-QUADRATIC CONTROLLERS

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Abstract

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Keywords

Linear quadratic control, Minimum variance control, Internal model control, Robustness, Discrete time systems.

Introduction

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No “extra” blank space is inserted between paragraphs. Most modern control theories are model based. A controller is said to be *robust* if the stability and performance of the closed-loop system are not severely compromised by moderate errors incorporated into the process model.

Process Conditions

That was a sub-heading (*Sub Heading* style); note that important words are capitalized. Process conditions do change with time and nonlinearities do change the process behavior in different operating regions.

Robustness and Performance

Consider the general discrete linear dynamic-stochastic model

$$\frac{\partial y}{\partial t} = \varepsilon(x)\frac{\partial x}{\partial x} + \delta(x)\frac{\partial x}{\partial y} + \eta(y)\frac{\partial^2 x}{\partial z^2} \qquad (1)$$

where the first term is the process transfer function. This paragraph is in *Continuing Paragraph* style - this unindented style is often needed after equations.

Assuming that the model of Eqn. (1) was used to design a minimum variance controller, the characteristic equation of the resulting closed-loop system would be given by something very strange:

$$\frac{\partial y}{\partial t} = \varepsilon(x)\frac{\partial x}{\partial x} + \delta(x)\frac{\partial x}{\partial y} + \eta(y)\frac{\partial^2 x}{\partial z^2} \qquad (2)$$

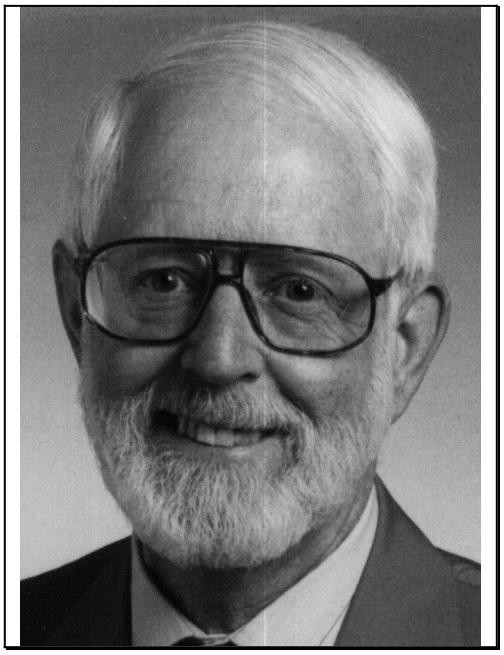

Figure 1. Scanned photo of an old chemical engineer.

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The polynomial $T(z^{-1})$ is the numerator term in the forecast expression for the disturbance (i.e., $N_{t+f+1} = (T(z^{-1})/h(z^{-1})\nabla^d)a_t$). The stability of the closed-loop system depends on the roots of this characteristic equation. The second term of this equation in the square brackets is a model/process mismatch term, as is illustrated in Fig. 2. Try to insert figures near where they are referenced, not together at the end of the paper.

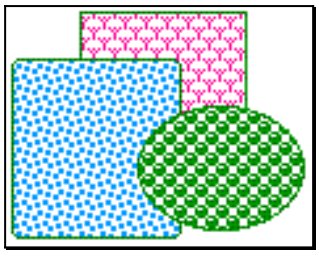

Figure 2. This is the figure caption for a typical OLE-embedded figure.

For comparison, Table 1 contains results determined by Hiebert (1980) using Powell's

dogleg algorithm (HYBRD1, HYBRD2 from the MINPACK library) and by Chen and Stadherr (1981) using a modified version of Powell's dogleg algorithm.

Conclusions

The results indicate that the prototype algorithm generally had less difficulty solving the equations, and appears to be more robust for the solution of the chemical equilibrium problems found by Dog (1958). That was a reference! In this short paper[1] we have presented a part of our work on the robustness of univariate LQG controllers.

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[1]This is a sample footnote that might appear in this column. It will be positioned under a separating two inch rule when you choose **Footnote** from the **Insert** menu.

Table 1. This is the Table Caption for a Page-Wide Table.

		Number of Function Evaluations Required for Solution					
SYSTEM	N	NEQLU1	NEQLU2	NEQLU3	NEQLU4	HYBRD1	HYBRD2
1a	2	31	45	7	6	23	26
2a	4	43	49	47	47	*	*
3a	2	104	90	40	32	181	177
4a	4	69	62	97	85	95	89
8a	10	22	24	26	26	31	34
8b	30	48	45	98	98	115	111
8c	40	63	106	152	152	92	190
12a	10	31	31	31	31	32	33
13a	10	20	20	20	20	21	21
15a	2	*	*	*	*	*	*
15b	2	*	*	67	54	*	*
16a	6	*	*	*	*	*	*
16b	6	*	*	114	117	51	86
16c	6	*	*	36	36	23	103
16d	6	*	*	84	84	*	75
17a	10	45	30	41	41	*	*
17b	10	17	16	46	33	*	*
17c	10	43	42	45	45	*	*
17d	10	39	40	41	41	38	39
17e	10	144	280	117	127	*	*
17f	10	80	*	94	156	*	*

* indicates failure of the subroutine to solve the system of equation

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Nomenclature

V_Z = velocity in the axial direction, m/s

ρ = density, kg/m^3

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